North Carolina Highway Bulletin

VOL. II FEBRUARY 1922 NO. 12

FEDERAL AID PROJECT NO. 49—LENOIR COUNTY—SHEET ASPHALT ON CONCRETE BASE

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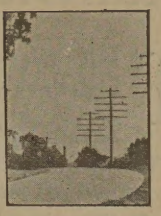
NORTH CAROLINA HIGHWAY BULLETIN



Vol. II, No. 12 H. K. WITHERSPOON, Editor FEBRUARY, 1922

School *for* Inspectors *on* Asphalt Work

A MEANS to furnish inspection for the large amount of bituminous paving which is to be carried on, has caused the North Carolina State Highway Commission through its Division of Tests and Investigations to establish a short course in bituminous laboratory and plant instruction so that it will be able to meet the situation and furnish adequate plant supervision and road inspection when the work begins.

The course is necessarily a short one and consists of taking the men into the laboratory for about a week to learn the different tests of the materials used and to attend lectures by the supervisors of this type of construction. After the laboratory and lecture courses are over, the men are to be taken to the asphalt plant for instruction in the duties of the plant inspector and then on the road for instruction regarding the construction methods to be used.

The men for this work were secured mostly from the different districts into which the work of the Highway Commission is divided. The number of men from each district is proportional to the amount of this class of construction to be carried on. This will allow the men to be located in the same district they came from and the only need for any change would be in the demand for emergency inspection from another part of the state.

To allow the most efficient instruction to be given within the alloted time, it was found necessary to divide the student inspectors into two classes. The first class reported February twentieth and the second February twenty-seventh.

The subjects which are taken up consist mainly as outlined:

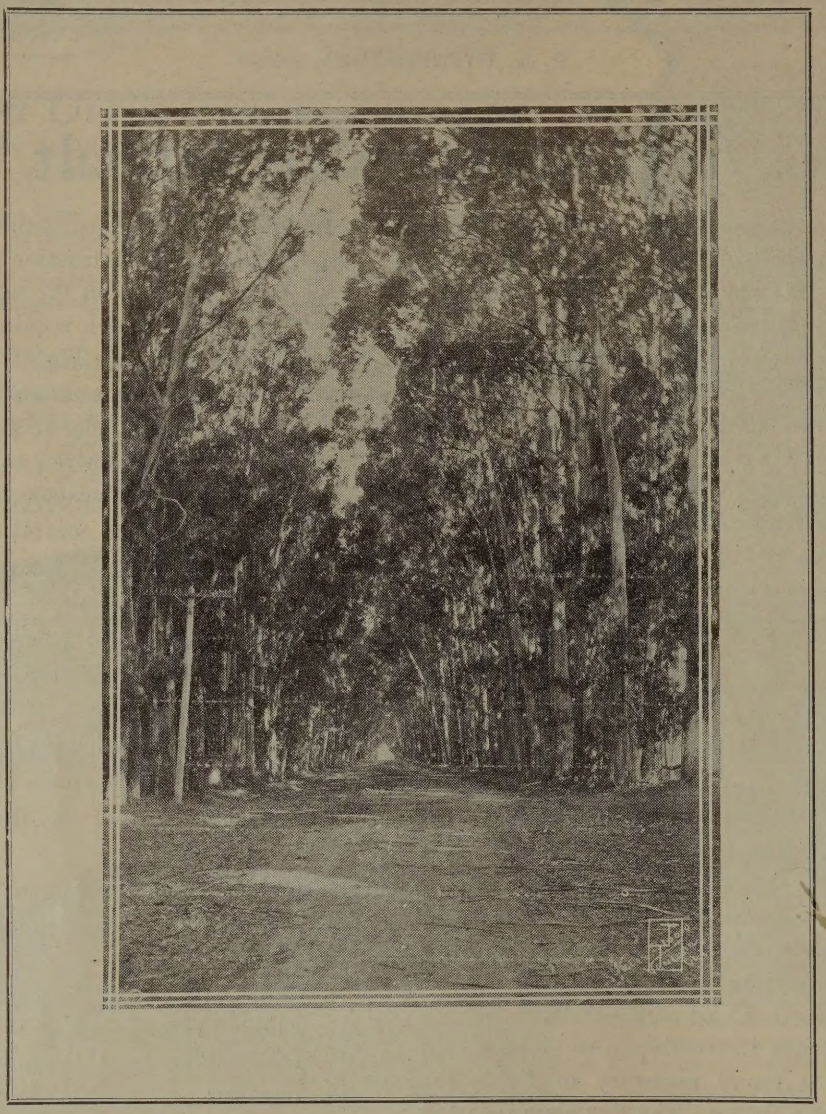
1. Qualifications of Plant Inspectors.
   Qualifications of Paving Inspectors.
2. Responsibility of Inspectors.
3. Sampling raw materials:
   Sand, Stone, Filler, Asphalt — Detail of methods for each and practical demonstrations with emphasis on the necessity for careful sampling of materials.
4. Testing raw materials in the field:
   The men to do all the testing of the various materials until they are thoroughly familiar with the work.
5. Asphalt Plant construction:
   Details of construction and operation of plants and emphasis on the various parts of the plant equipment which require careful inspection.
6. Asphalt Specifications:
   Sheet Asphalt wearing surface.
   Bituminous Concrete-fine aggregate type.
   Bituminous Concrete-coarse aggregate type.
   Bituminous Macadam-penetration method.
7. Measurement and control of proportions.
8. The calculations to secure the best mixture from available materials.
9. Explanations and performance of the various field tests for determining the voids, etc., in materials.
10. Sampling the various types of mixtures.
11. Control of temperatures at the plant.
12. Characteristics of the different bituminous mixtures.
13. Care of testing equipment by the inspector.
14. Cooperation between the plant and paving inspector.
15. Cooperation with the contractor.
16. Fluxing refined asphalt at the plant.
17. Dispatching from the plant.
18. Reports:
    The preparation of complete reports, cost data, and keeping of plant records.
19. Preparation of base course.
20. General methods of construction.
21. Sampling on the road and check samples.

As soon as the men have finished the course in the laboratory, they will be returned to their respective districts to await plant instruction provided it is not possible give them this work as soon as they finish in the laboratory. Twelve men constitute a class in laboratory instruction, but not more than four will be placed at the plant at one time as it would be a handicap to the contractor and not allow enough attention to be given each inspector by the supervisor if the number was increased. When the plant and road instruction is completed, the men will be returned to the districts to be assigned to plant work.

(Continued on page 12)

Planting Trees *on* Southern California Highways

THE article regarding tree planting along public highways which appeared in the December number of the North Carolina Bulletin finds a responsive echo in the minds of the people of Southern California. The planting of trees beside the highways of the country is a movement which is gaining favor wherever it has been brought to the public's notice. There is a practical as well as an artistic benefit derived from a well-shaded road, particularly where it is used by numbers of motorists, as well as by the residents of a County. The opportunity to draw up for a few minutes rest under the green canopy of wayside trees, or to take lunch beneath their shade is an advantage which not only pleases those to whom it is afforded, but it has an advertising value by being remembered and spoken about when the traveller reaches his home State.



So, too, the dust is never blown across those highways flanked with trees, and travelling is always made more pleasant, especially during hot days. From the standpoint of picturesqueness there is of course no comparison between the highway beautified by lines of tall trees and a bare, bald roadway winding through a country without a solitary tree-trunk to break the monotony of the landscape. The contrast in such cases is so vivid that the traveller never forgets it.

In Southern California the planting of trees and shrubs along the highways has been going on for years. The Automobile Club of Southern California, in addition to sign-posting all the roads and highways, has always been enthusiastically aiding this movement. Eucalyptus trees, pepper trees, cypress, palms and pines have been set out in the country, the towns and the cities, and the effect has been productive of keen appreciation by not only all visitors, but all citizens.

The State of California has passed laws for planting trees and shrubs along its highways, and appropriated money for that purpose. The State Highway Commission has jurisdiction over the State Highways and the County Forestry Department of the different Counties has charge of the roads through the Counties. No one is allowed to cut down or even to trim a tree along the highways without the authority from those who are in charge of the work. The funds provide for preservation of trees and shrubs.

Resident Engineers, Notice!

Take some pictures of that project that you are on and send them together with a short description of the most interesting or unusual features of your job to the Editor. If you prefer, write the story yourself giving in a clear, concise manner just how the work is being carried on, what equipment is being used, etc.

Control *of* Asphalt Pavement Construction

By E. R. Olbrich, *Construction Engineer, N. C. State Highway Commission.*

For the purpose of this discussion the subject matter has been divided under four general topics.

1. *Plant Control*, which includes testing the quality of the materials used in an asphalt surface, and the inspection of the process of combining these materials into the finished mix.

2. *Control on the Road*, or control of the laying of the mix on the prepared foundation.

3. *Laboratory Control*, which serves as a check on both the Plant Inspector and Road Inspector.

4. *Discussion of the Specifications.*

DEFINITION OF TERMS

The first two topics of "Plant Control" and "Control on the Road" will be discussed in this paper.

Before taking up these topics I believe it would be advisable to give a definition of a few terms commonly used in asphalt work, concerning the meaning of which there is often more or less confusion.

Bitumens are Hydrocarbons soluble in Carbon Disulphide. This includes both asphalts and tars. Asphalt is the term applied to solid or semisolid native bitumens, or bitumens obtained by refining petroleum oil.

Refined Asphalt is asphalt which has been subjected to a refining process, but which is ordinarily too hard for use in the manufacture of bituminous pavements.

Asphalt Flux is the term applied to liquid asphalt bitumens which are employed to soften the refined asphalt.

Asphalt Cement (A. C.) is the term applied to asphalt material, either fluxed or unfluxed, and of proper consistency to be employed as a binder in an asphalt pavement mixture.

Filler is finely divided mineral matter most of which will pass a 200 mesh screen, used to fill the voids in the fine aggregate of an asphalt mix. Portland cement or limestone dust is generally employed. Clay, although of requisite fineness, is unsuitable as it tends to "ball-up" or form lumps when mixeed with the asphalt cement. The clay particles inside of these lumps remain uncoated with the asphalt cement.

The Theory of Asphalt Pavements

The materials used in asphalt pavement construction are a mineral aggregate composed of sand and filler in the case of sheet asphalt, or stone, sand and filler in the case of bituminous concrete such as Topeka or Warrenite, and a binder which is the asphaltic cement.

These materials are combined with the following purpose in mind.

1. To so grade the aggregate as to reduce the voids in the sand or sand and stone to a minimum, and to reduce these voids still further by the use of a mineral filler so that the aggregate approaches as nearly as possible solid stone in density. It is desirable not only to reduce the proportion of voids, but also their proportionate size to a minimum, so that the least amount of asphalt cement will be required.

2 To add sufficient asphaltic cement of proper consistency to give a thin coating of binder to the surface of the stone, sand and filler, so that, after maximum compression of the mixture by rolling the voids in the aggregate shall have been completely filled without leaving an excess of asphaltic cement.

This will produce a dense elastic pavement, impervious to water, one which will have maximum stability, or resistance to shoving and pushing, under traffic.

Plant Control

There are various types of asphalt plants, designed to meet the requirement of either permanent location or portability.

1. Permanent (or city plants).

2. Portable Plants.

   (a) Railroad Plants.

   (b) Two and three Unit Plants.

We will take up Plant Control, as nearly as possible, in the same sequence as the various steps in the operation of the plant.

1. *Testing of Materials used in Mix.*

Before beginning work on an asphalt job it is very necessary that the materials which the contractor proposes to use in the mix shall have been approved by the laboratory. It is therefore desirable that the contractor submit samples of the materials as early as possible to the Division of Tests in order to avoid delay in starting the work.

The Plant Inspector makes daily tests on the materials, particularly on the consistency or penetration of the asphalt cement and the grading of the sand to satisfy himself that they are running uniform, and check samples are sent to the laboratory at regular intervals.

Whenever there is a change in any of the materials used in the mix, that is, the source or character of the material is changed, a sample of the new material must be submitted to and approved by the Division of Tests before it may be used on the job.

2. *Use of Local Sands.*

(a) *Stock-Piling.*

Where local sand is used the grading of the sand is apt to vary considerably and it is necessary for the inspector to make frequent tests to determine its suitability. For this reason it is desirable to have on hand a sufficient quantity of sand, which has been tested and found acceptable, to permit of at least one day's run. This gives the inspector an opportunity to test the grading of the sand which it is expected will be used the following day. Therefore, a stock pile equivalent to one day's run, or a minimum of 50 tons, is required.

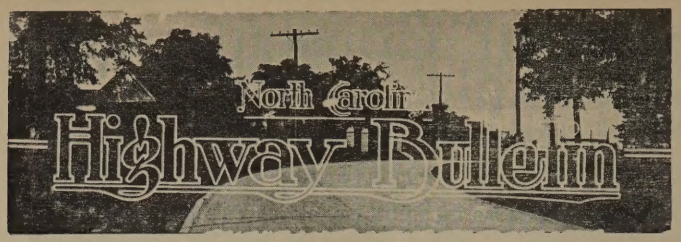
(b) *Proportioning Sands.*

It may not be possible to obtain a local sand which will meet both the structural and grading requirements in itself. It may be hard, clean and sharp, but show a coarse grading. It may then be combined with another sand of good quality but showing a fine grading to obtain a combined sand of satisfactory grading. Sometimes it may be necessary to combine three sands to obtain a satisfactory grading. The proportion of each sand to be used is determined by the Division of Tests and the Plant Inspector.

3. *Drying and Heating the Materials used in the Mix.*

The asphalt cement in the road surface at ordinary temperatures must be of such consistency as to give sufficient stability to the mixture under traffic. The asphalt cement at ordinary air temperatures is too stiff and hard to permit of mixing and it must therefore be rendered liquid by heating to a proper temperature to produce a plastic mix when it is combined with the mineral aggregate. As the asphalt cement comprises, roughly only from 5 to 15% of the total mix, it is necessary to heat the aggregate, as cold sand or stone would cool the small proportion of asphalt cement, heated to a safe temperature, so that it would be too stiff to mix effectively.

(Continued on page 8)



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Volume II **FEBRUARY, 1922** **Number 12**

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Editorials

Without competent inspection of materials it is next to impossible to secure a first class job on any kind of hard surface road work, and particularly on asphalt work on account of the many different materials which are combined to give the finished product. Through the Division of Tests and Investigations the Commission is holding a school for the men who, when construction work opens up, will be in charge of plant inspection and road supervision. Assistant Engineer G. W. Hutchison has outlined in a brief way in this issue the course that is being given the inspectors to prepare them for their duties.

This issue of the Bulletin, which does not contain the usual variety of reading matter, is intended primarily for the information of resident engineers and inspectors on hard surface highway work throughout the State. Valuable information is contained in the articles on "Control of Asphalt Construction" and "Bituminous Specifications and Laboratory Control" and they should be carefully read by the engineers mentioned above. These talks were delivered at the last meeting of the District Engineers and are published here for the benefit of those who were not present.

Bids will be received on March 15th, on 67.18 miles of roadwork, 35.47 miles being of hard surface construction. This brings the total mileage of projects advertised for letting since January 1, 1922 to 304.16 miles or nearly one-third of the mileage planned by the Commission for letting this year. The Commission is making an effort to get under contract as much mileage as possible so that when the construction season opens up the work of actual construction can be rapidly pushed.

The March issue of the Bulletin will contain an article which will be of great interest and importance to every contractor who is doing, or who contemplates doing, State highway construction. This article, among other things will give a short digest of the new specifications which have just been compiled and it is important that every contractor familiarize himself with the changes that have been made. Resident Engineers please note the request at the foot of page 4 and act accordingly.

An interesting article on "Planting Trees On Southern California Highways" will be found on page 4. This write-up was occasioned by an article on the subject of tree planting which appeared in the December issue of the Bulletin, a copy of which was sent to California. With the coming of a State system of highways some thought should be given to planting trees alongside of the road.

Contracts Awarded February 7th

CONTRACTS covering the construction of 84.95 miles of highway and 4 bridge projects were awarded on February 7th at the largest letting yet held by the Commission. On the fourteen projects which were advertised for letting on the above date one hundred and seventy bids were received, a larger number than had been received at any previous letting. The projects which were awarded were fairly representative ones, practically all types of road being included and the work located in almost every section of North Carolina. The prices at which the work was let were very favorable and give evidence of a considerable decline in the cost of road construction, the average cost of the hard surface construction being less than $27,000 per mile as compared with over $40,000 per mile a year ago.

After tabulation and a careful comparison of the bids the contracts were awarded as follows:

R. G. Lassiter & Co., of Oxford, N. C., were the successful bidders for Project No. 125, Edgecombe County consisting of 15.11 miles of road between Rocky Mount and Tarboro, the bid price for the grading, structures and Topeka surfacing being approximately $388,000.

Project No. 183-B, consisting of the bridges and culverts on the highway between Greenville and Bethe Pitt County, was awarded to B. J. Boyles of Wilson, N. C., for $29,403.00.

J..A. Marrow of Clarksville, Va., was awarded the contract for grading and building the structures on the 14.35 miles of highway between Greenville and the Beaufort County Line, Project No. 185, his bid being $30,-376.40.

Project No. 195, Washington County, 15.18 miles of highway between the Martin County line and Pleasant Grove Siding was divided between two contractors, L. M. Lee & Company, of Emporia, Va., being awarded the grading and the sand clay surfacing for $38,539.20, while the structures were let to B. J. Boyles of Wilson, for $21,114.75.

Project 313, Brunswick County, between Causeway and Leland, was awarded to the Southern Willite Paving Company of Richmond, Va., and to the Roanoke Iron & Bridge Works of Roanoke, Va.; the former to do the grading and surface the road with willite pavement for $86,145-.60, and the latter to construct the bridges for $9,663.35, making a total cost of $95,808.95 for the 3.44 miles included in the project.

The Hagedorn Construction Co., of Winston-Salem, was awarded 15.82 miles of road, and structures on same, between Southport and Supply, Brunswick County. The project, known as No. 314, will be graded and surfaced with sand clay and will cost, including structures and engineering, approximately $110,000.

Section "A" of Project No. 364, Onslow County was awarded to R. E. Martin, of Mountain City, Tenn., for $40,574.00. The project is located between Dixon and the Pender County line, a distance of 9.95 miles and will be graded and surfaced with sand clay.

Geo. W. Kane, of Roxboro was low bidder on project No. 453, Orange County, and was awarded the contract for $30,651.20. The contract covers the construction of a modern reinforced concrete bridge over the Eno river just east of Hillsboro, replacing the old steel structure now in use. The new structure will be located upstream from the present bridge and the dangerous approach to the bridge from the east will be eliminated.

The short link between the concrete highway west of Burlington and the end of the paved street of the city, Project No. 505 will be paved with sheet asphalt by the Hedrick Construction Co., of Lexington, N. C. the contract having been left to this firm for approximately $14,-000.

Project No. 526, a link of the Central Highway in Davidson between Thomasville and the Guilford County Line, was awarded to the Hagedorn Construction Co., of Lexington and the structures on the same project to Heilig and Sherill, of Winston Salem. The bid of the former was $98,506.00 for grading and surfacing with plain concrete the 3.77 miles included in the project while the structures were let to the latter firm for $7,593.00.

The Concrete Steel Bridge Co., of Clarksburg, W. Va., will build project No. 606, a bridge over Rocky River, on the line between Stanly and Anson Counties, on the route between Albemarle and Wadesboro. The bridge, which is to be of standard reinforced concrete construction will cost approximately $50,000.00

W. E. Graham, of Salisbury, was awarded the contract for 6.91 miles of road in Surry-Wilkes Counties between State Road and Doughton. The project, designated as No. 760, will cost approximately $22,000.00, for the grading, structures, and surfacing with topsoil.

Project No. 880, a bridge in Rutherford Co., between Forest City and Ellenboro, was awarded to the Austin Bros. Bridge Co., of Atlanta, Ga., for $22,435.85.

He tried to cross the railroad track
Before the rushing train.
They put the pieces in a sack—
But couldn't find the brain!

Control *of* Asphalt Pavement Construction

(Continued from page 5)

(a) *Heating the Refined Asphalt, Fluxing.*

The refined asphalt is shipped to the plant in barrels, drums, or where storage facility is provided, in tank cars. This last method of shipment is cheaper and more convenient as it is possible to obtain the refined asphalt already fluxed to the proper consistency.

When the refined asphalt is too hard it is "fluxed" or softened by adding a light asphaltic oil until the desired consistency or penetration is reached as determined by the use of the Penetration machine. If the refined asphalt is too soft a refined asphalt of harder consistency is added, or air is blown into the soft asphalt, which has a gradual hardening effect upon it.

The asphalt cement is heated in tanks either by fire in direct contact with the tank, or by steam coils. The later method is preferable as there is not the danger of overheating it. The asphalt cement should not be heated to a temperature higher than 300 degrees—325 degrees F. It should be agitated to prevent the fine material from settling to the bottom. Care should be exercised in heating the asphalt cement to prevent its foaming over the tank, should water be present.

(b) *Heating the Aggregate.*

Continuous drier method for Sheet Asphalt or Topeka.

The sand and stone are piled as closely as possible to the elevator which conveys them to the heating drum. If several sands are being combined they should be kept in separate piles and fed into the conveyor in proper proportions. It is very important that the sand and stone be kept clean and free from dirt and foreign matter. The sand and stone are fed into the conveyor in approximately the proportions used in the mix and carried into the heating drum. After heating they are lifted in an elevator, passed over a 10 mesh screen, and separated into sand and stone storage bins over the mixing platform. The sand and stone should not be heated in excess of 350-375 degrees F., otherwise the asphalt cement coming in contact with it later in the mixer will be overheated.

The inspector should take a sample of the heated sand and check the grading, and satisfy himself that all the stone has been separated from the sand. Unless provision is made to prevent it, much of the fine mateerial or dust contained in the sand, will be lost in the heating drum by passing out the flue. This would give a different grading of the heated sand in the storage bin as compared with the unheated sand in the pile.

If it is necessary to shut down the plant for any length of time the temperature of the sand and stone in the storage bins should be checked. If it has become too cold (depending on length of haul and temperature of air) it should be dumped through pipes provided in the bottom of the box and reheated. This is important to prevent the complete loss of a finished batch later due to the low temperature of the mix, resulting from the use of the cooled aggregate.

(c) *Use of Pyrometers.*

Pyrometers are mechanical devices used to record the temperature of the asphalt cement in the heating tank and the temperature of the aggregate as it comes out of the heating drum. They should be a part of the equipment of every asphalt plant and so located as to be easily visible to the fireman or inspector.

4. *Proportioning the Mix.* (Formula)

(a) Experience has produced certain average or standard mixtures for the various types of asphalt pavements, and which may serve as a guide for a trial mix. An average grading for sheet asphalt is as follows—

Asphalt Cement	10.5
Filler	12.5
Sand	77.0
	100.0%

(b) Factors affecting the percentages of the mix. The sand aggregate may be considered as the basis of the mix, and the percentages of asphalt cement and filler as the variables, which vary with the following factors.

1. The grading of the sand, Proportion of Voids.
2. The structure of the sand, that is the shape and surface of the sand grains.

A sand composed of grains which are rounded in shape will have more voids in it and take more asphalt cement and filler than a sharp irregular grained sand.

A sand whose grains present a smooth surface under the microscope will require less asphalt cement than a sand with grains having a rough and pitted surface.

The amount of asphalt cement and filler must be varied by trial until a mix with the best working qualities and greatest density is secured. This result is obtained by cooperation of the plant and road inspector and by density determination made in the laboratory.

(c) An average grading for Topeka as given by Richardson is:

Asphalt Cement	9.0
Filler	10.0
Stone	30.0
Sand	51.0
	100.0%

The only function of the small amount of stone in Topeka is to replace an equivalent volume of sand and make a cheaper surface. Stone is generally cheaper than commercial sand, and the stone requires less asphalt cement and filler than an equivalent volume of sand.

It will be noted that in the Topeka mix you have 1½% less asphaltic cement and 2½% less filler than in the sheet asphalt mix, but three-eighths of the aggregate is stone.

5. *Combination of the Materials (Mixing)*

The asphalt cement after it has been heated to the proper temperature is pumped from the tank and carried in a pipe line to the mixing platform. Having all our materials at the platform and heated to the proper temperature we are now ready to combine them in the proper proportions.

In mixing sheet asphalt and Topeka the proportioning is done *by weight.* We will follow through the operations in mixing a batch of Topeka. The sand and stone are passed from the storage bins into a weighing-box mounted on a platform scale and weighed out in proper proportion. The asphalt cement is allowed to run from the pipe line into the asphalt bucket which is suspended from a beam or dial scale. It is very essential that these scales be checked frequently as upon their accuracy depends the correctness of the proportions in the mix. After weighing the sand and stone are dumped into the mixer-box.

The Mixer is a plain or steam-jacketed iron box provided with two horizontal shafts to which blades are attached. These blades have a pitch similar to those on a propellor and when in motion throw the materials from the sides and ends of the box toward the middle. They revolve at from 60-80 r. p. m. After a time the blades and liners of the box become worn, especially when the mixture contains stone, and must be replaced.

As stated the sand and stone are weighed and dumped into mixer-box. The filler (or dust) is added and is usually measured in a bucket or box, the volume having been checked by weight. The filler is not heated in the drum with the sand and stone, as much of it would pass up the flue because of its fineness, but is heated by contact with the sand and stone.

The sand, stone, and filler are allowed to be thoroughly mixed before adding the asphalt cement, which is then poured in gradually from one end of the mixer-box to the other. After the asphalt cement has all been added the mixing is continued for one minute, the bottom of the mixer-box is then opened and the finished mixture dropped into the waiting truck below ready to be transported to the road.

6. *Method of Proportioning and Mixing Warrenite.*

The Warrenite mixer differs from the mixer used for sheet asphalt and Topeka in these main features—

1. The proportioning of the sand, stone and screening in the mix is based on the weight of the dry materials, but is done by measuring the moist or wet sand and stone into the heating drum in level wheelbarrow loads, whose weight equivalent in dry sand, stone and screenings is known.
2. The Batch-Drier or heating drum of the Warrenite plant has a larger capacity than the continuous drier of the sheet asphalt or Topeka mixer, capable of drying and heating a batch of 3000 lbs. or more.

Sufficient sand, stone, and screenings is measured out in wheelbarrows and emptied into a batch box. When the aggregate has all been measured into the batch box it is emptied into the drier and the entire batch heated as a unit. For this reason it is not necessary to separate the sand, stone, and screenings into storage bins after heating as the batch has already been proportioned and as soon as it is heated to the proper temperature it is ready to be dumped into the mixer-box, and the proper weight of asphalt cement and filler added as in the case of sheet asphalt or Topeka.

7. *Visual Inspection of the Mix.*

The temperature of the mix after it is dumped from the mixer into the truck should be observed, and the appearance of the mixture noted. If it is overheated this will be indicated by a blue vapor arising from it. If the mix is of the right temperature, but contains an excess of asphalt cement, it will slump down and spread out and if the excess is marked, free asphalt cement will gradually appear on the surface. It must be remembered, however, that when the mix is heated to a high temperature it also tends to slump down.

If the mix has a dry appearance and stands up stiffly it indicates a deficiency of asphalt cement, or perhaps an excess of filler.

The stain obtained by the "Pat Test" with sheet asphalt indicates deficiency or excess of asphalt cement with that type of mix but is of no service in mixtures containing stone.

TRANSPORTATION OF THE MIXTURE TO THE ROAD

The mixture should be hauled from the plant in trucks or wagons with metal or metal-lined bodies, which have been lightly painted with oil to prevent the mixture from adhering to the body.

When the haul to the job is long, or the air cold and windy, the mixture shall be protected with a canvas. In the case of rain, no more material shall be mixed at the plant, but the mixture already in transit to the road may be laid and rolled provided it has not become too chilled and water-soaked, in which case it must be rejected.

CONTROL ON THE ROAD

1. *Co-operation between Plant and Road Inspector.*

The Plant Inspector does not see the mix after it leaves the plant and cannot judge as to the workability or temperature of the mix when it arrives on the road, and must depend on the Road Inspector to inform him on these points. The Road Inspector should therefore make a

2. *Visual Inspection of the Mix*

And note the following points, advising the Plant Inspector if, in his judgment, the mix should be adjusted.

(a) Does the mix show an excess of free asphalt cement on top of the load before it is dumped from the truck?

(b) Does the mix spread and rake satisfactorily? If not is it due to,

1. a deficiency of asphalt cement,
2. excess of filler,
3. low temperature of mix?

3. *Temperature Record of Each Load of Mix.*

The Road Inspector must make a record of the temperature of each load of mix and enter it upon his report sheet. The Engineer will set a certain desired temperature of the mix, and a variation of 30 degrees F. each way will be allowed from this desired temperature.

4. *Temperature of Air and Weather Conditions.*

Generally speaking, an asphalt mixture should not be laid when the temperature of the air is less than 50 degrees F. This may be qualified by the statement that if the temperature of the air is about 45 degrees F. and is rising it is permissible to begin laying the mix. If the temperature is at 50 degrees F., and is falling, laying of the mix should not begin.

Another factor is a cold wind. A cold wind at 50-60 degrees F. may have a decidedly more chilling effect on the surface of the mixture as it is being laid than a still air temperature of 10-15 degrees less. A cold wind will chill the surface of the mix and produce a honey-combed surface which is difficult to seal by rolling.

5. *Condition of the Concrete Base.*

The concrete base should be clean, dry and of uniform cross section and present a fairly rough surface if no binder course is used, to insure anchorage for the asphalt pavement and guard against pushing of the surface. The concrete shoulders or edging should have a depth equal to the thickness of the asphalt topping, and should have a clean-cut finish.

The inspector should ascertain if satisfactory drainage has been provided at sag points in the grade, otherwise water will collect under the asphalt surface at these points. Holes should be drilled through the concrete base at the low points to permit the water to drain off.

6. *Dumping, Spreading and Raking.*

The mixture should be dumped in a pile outside the area over which it is to be spread, so that it is not necessary to rehandle the entire pile, when it is shoveled into place. This insures a loose mixture which is uniformly spread and raked. The tines of the rakes should be slightly longer than the depth of the loose mixture and care should be exercised to break up all lumps. The workmen will not be permitted to stand in the loose mixture.

The loose mixture is spread and raked to a depth such, that after full compression the finished surface will be of the proper depth. A compacted depth of two inches will require about 2½ inches to 2⅝ inches of loose mixture.

7. *Spreading the Seal Coat.*

Where a mixed seal coat is used to seal the surface of a coarse mix it should be applied from a dumping board at the side of the road so that it will not be necessary for the workmen to stand in the mixture while spreading and raking it. The seal coat should be spread on the surface mixture before it is rolled, or after initial compaction. In either case it is essential to have the seal coat hot to facilitate spreading.

8. *Rolling.*

The new specifications require the use of two rollers, a light tandem roller of about eight tons for initial compression and 10-12 ton three wheel roller for final compression.

The total weight and the width of tread of the rollers should be checked. The tread of the roller should be tested with a straight edge and the condition of the bearings of the roller noted, as a tread that is not true, and loose bearings will produce a wavy, uneven surface,

When two rollers are used the final rolling should follow the initial rolling as closely as possible. The rolling should first proceed in a longitudinal direction followed by a diagonal rolling until compression is complete. Care should be exercised in reversing the direction of the roller, as a sudden reversal tends to displace the surface and cause a wave.

The rolling should continue until final compression is obtained and at a rate not exceeding 150 sq. yds. per hour.

9. *Compression around Structures in Road.*

Where structures such as manholes occur in the road, the sides shall be painted with a light asphaltic oil and the compression around the structure shall be obtained by hand—tamping with hot smoothing irons, care being taken to prevent burning the mixture.

10. *Making Joints.*

Joints may be made by running over the edge of the mixture and sealing it. It is then cut back to a point where the compacted surface is of proper depth and so as to present a granular surface. On resuming work the hot mix is compacted against this clean granular surface and finished off with hot smoothing irons if necessary.

A Rope-Joint as used in sheet asphalt is made by laying a rope across the road in the loose mix and rolling over it. It is then pulled out of the mix.

11. *Finishing the Surface.*

(a) A close surface, as sheet asphalt or Topeka is finished by sweeping Portland Cement or limestone dust into the surface.

(b) An Open Surface, one in which stone predominates, is finished with a seal coat of asphalt cement mixed with either sand, or sand and screenings.

(c) The seal coat is either

1. A mixed Coat prepared in the mixer at the plant, and spread and rolled into the surface course, or
2. A Flush Coat of asphalt cement flushed over the surface course before final compression. It is worked into the surface by the use of squeegees and covered over with screenings before final rolling.

Bituminous Specifications *and* Laboratory Control

By E. E. Strohn, *Construction Engineer, N. C. State Highway Commission.*

Bituminous mixtures ordinarily prepared at a Mixing or Paving Plant, are laid on a prepared Base Course of Portland Cement Concrete, Broken Stone, or Gravel.

They are usually spread to a thickness of from two (2) to three (3) inches and compacted by means of a power-roller weighing from five (5) to twelve (12) tons, depending on the type of roller used. After compaction, if the surface of the pavement has an open texture, a Seal Coat of some sort is applied, while if it has a closed surface, a thin covering of Portland Cement or Limestone Dust is applied to give it a finished appearance.

From the engineer's standpoint, the work is divided into four classes, namely:

Specifications, or Types of Mixture
Laboratory Control of Paving Mixture
Plant Control of Paving Mixture
Road Control, or Road Construction

The balance of this paper will be devoted to discussing the different Types, or Specifications, their outstanding characteristics, and the Laboratory Control of their provisions.

Since Asphaltic, or Bituminous Paving Mixtures have different characteristics, depending on the size and gradation of their respective mineral aggregates, it is best to divide them into five classes, according to these characteristics, and considering only the Specifications under which we are working at the present time in this State.

1. *Coarse Graded Aggregate Bituminous Concrete*, in which the mineral aggregate consists of a combination of coarse and fine aggregates so proportioned that the coarse predominates, and the fine serves as a void-filling medium.

2. *Fine Graded Aggregate Bituminous Concrete*, in which the mineral aggregate consists of small sized broken stone and sand so proportioned that the sand greatly predominates over the stone, and thus separates the larger particles from each other.

3. *Sheet Asphalt Pavement*, which consists of a bituminous concrete Binder Course of Sand and Stone, and a carefully graded mineral aggregate of Sand and Filler which is mixed with Asphalt Cement in such proportions as to produce a very dense surface mixture.

4. *Rock Asphalt Surface Course*, which is a natural bituminous sandstone suitably prepared by crushing for spreading and rolling similar to Sheet Asphalt Surface Course. It differs from the latter mixture in that it is laid cold, and does not require a Mixing Plan.

5. *Bituminous Macadam, Penetration Method.* This surface course rightly does not come in this group, but will be included for purposes of classification of all our Types. According to the definition of the American Society of Civil Engineers, a Bituminous Macadam Surface Course "is one having a wearing course of macadam with the interstices filled by penetration methods with a bituminous binder."

Foundations

Before taking up the detailed study of each of these Specifications, it may be well to consider foundations, briefly. While several different types have been utilized, for asphaltic surface mixtures, the only one which we need consider is Portland Cement Concrete. Without going into detailed discussion of Specifications for this foundation, we shall take up the importance of a good foundation.

In the past, it seems to have been the mistaken idea of some Engineers that the Base Course is of secondary importance, but failure of the Wearing Surface proper, due to the collapse of the foundation caused by faulty drainage or faulty construction, have shown us their mistake. We cannot exercise too much care in this part of the work, and in fact, we are possibly safe in saying that no Asphalt pavement is stronger than any weak spots in its foundation.

In other words, if we are to have a 1:3:6 mix on our base, then by all means let us get it. Let us have our full depth and have the Header Curbs of the proper height.

It has been found the best practice to have the Base Course slightly roughened, so that the Wearing Surface will be less likely to slip due to not having the proper bond with the Base.

Taking up the types of Asphaltic Wearing Surface Courses in their numerical order as given above, we have:

Coarse Graded Aggregate Bituminous Concrete

The chief characteristic of a bituminous mixture of this type is that it is composed of mineral aggregate consisting of broken stone ranging in size from 1¼" to ¼", and sand and mineral filler all to pass a ¼" sieve.

The stone is to be of good quality, having a coefficient of wear of not less than eight (8), and to be of fairly good gradation. This latter quality is particularly necessary in order to allow the maximum amount of interlocking of the coarser particles under compaction and in this manner have the minimum percentage of voids in our finished pavement. It is not considered necessary that the fine aggregate be of a standard sheet asphalt grading, in that this type derives its mechanical stability from the interlocking of the coarse aggregate particles embedded in the bituminous mortar which completely fills all voids in the coarse aggregate. It is essential, however, that the sand be of good quality, of sharp angular shape, and clean.

In mixtures of this type, Filler is sometimes added to give additional density and toughness to the pavement, but in most cases, stone screenings are used as an intermediate aggregate, which contains a certain amount of stone dust which makes an excellent filler. When the proportions are properly cared for, this type gives a very good, dense, pavement in that we have a regular gradation from maximum sized to minimum sized particles.

In this pavement, due to the large aggregate, the surface after compression presents an open texture, and usually a seal-coat of either mixed sand and asphalt cement, or a flush seal-coat of asphalt cement with a mineral covering, is applied to close all surface voids.

The penetration requirements on the Asphaltic Cement for this type depend on the climate, and for this section of the country it should preferably be between fifty and sixty, with fifty-five possibly being the best point.

It may be well to state that Refined Tars have been used in mixtures of this sort, but have not been found generally successful, due to their marked susceptibility to changes in temperature. That is, in cold weather they have a tendency to check or crack, and in warm weather to become extremely soft, both of which faults are quite detrimental to the success of any pavement.

Fairly representative formulae for this specification follow:

A. C.	6.5%	or	A. C.	6.0%
Sand	29.5		Sand	18.0
Filler	4.0		Screenings	20.4
Stone	60.0		Stone	56.0
	100.0%			100.0%

The voids in the mineral aggregate in the above mixture would be about 16-18%, depending of course on the grading of the respective aggregates; while the voids in the finished pavement should be not more than 2-4%.

Fine Graded Aggregate Bituminous Concrete

In a mixture of this type, due to the preponderance of fine aggregate, the stability depends on the grading of the fine aggregate.

The stone particles, which range in size from ½ inch to the No. 10 mesh, add nothing to the stability, as they are practically in suspension in the bituminous mortar. The reason for this is that if sufficient of the stone were introduced into the pavement to allow for interlocking, the one-sized coarse aggregate would cause it to be very unstable, and we would have a wearing surface that would be liable to push and become wavy. They do, however, in a sense, add to the density of the mixture and also to the cheapness of the pavement.

From this it easily can be seen that in this type, it is necessary to obtain a well-graded fine aggregate. Engineers of other States and municipalities have discovered that failure of pavements of this kind under their supervision can be traced to disregard of this point. Filler is usually added to the mixture to give it added toughness and density up to a point where it will not interfere with the workability of the mixture on the road.

There has been a tendency in the past few years to increase the size of the stone to ¾ inch, and increase the percentage of stone accordingly. This adds considerably to the stability of the mixture, in that we have an interlocking of a fairly well graded coarse aggregate in connection with a very well graded fine aggregate. This is called a Modified Topeka, and compares favorably with our new specification.

Requirements for the penetration of Asphaltic Cement usually range from 45-65, with 50 being a good working point in this section of the country.

A representative formula for this type would be:

A. C.	9.0%
Filler	8.0
Sand	48.0
Stone	35.0
	100.0%

The mineral aggregate in the formula given above, considering it to have a fairly good grading, would contain about 20% voids, while the compacted surface coarse should contain not more than 2-3% voids after final compression.

Sheet Asphalt Wearing Surface

A pavement of this type consists of a binder course composed of broken stone and Asphaltic Cement, or broken stone, sand, and Asphalt Cement, and a Wearing Surface composed of a well graded sand, mineral filler and Asphalt Cement.

The Binder Course is used to true up inequalities in the Base Course and to prevent pushing and slipping of the Wearing Surface proper. The only type which we need to discuss here is the latter, or "close" Binder, which is composed of about 5% Asphalt Cement, 25% sand, and 70% stone, and is laid on the prepared Base Course to a finished depth of approximately one and one-half inches (1½"). It is not considered desirable to have this course entirely closed, with no surface voids, as this would defeat the very purpose of the Binder course.

The sand for the Wearing Surface should consist of clean, sharp grains, free from dirt or clay, and to conform as closely as possible to the following grading as a standard:

Passing a No. 10 mesh sieve	23%
Passing a No. 40 mesh sieve	43%
Passing a No. 80 mesh sieve	34%

Since we add a mineral filler to our aggregate which contains a large amount of No. 200 mesh material, and which is more suitable as a filler than No. 200 mesh sand grains, this part of the sand is considered undesirable. Since sands nearly conforming to the above gradation are scarce, it is often necessary to combine two or more sands in order to obtain a grading which complies with the requirements.

The Filler should be either a pulverized limestone or a Portland Cement, and is introduced into the mixture to give it added density and toughness, and render it more impervious to moisture, due to its void-filling capacity. An ordinary heavy-traffic Surface Course mixture will contain from 12% to 18% mineral filler, of which usually 65-90% is No. 200 mesh material.

The stability and wearing qualities of a Sheet Asphalt pavement is dependent first upon the gradation of the mineral aggregate, and second, on the consistency and proper proportion of Asphalt Cement. The density usually required for the Wearing Surface course should be not less than 2.20, which allows for about 4% of voids in the compressed pavement.

The penetration requirements for Asphaltic Cement for this type range from 40-55, depending on climatic and traffic conditions. Usually no change in the penetration is made for the Binder Course.

A typical Wearing Surface course formula would be:

A. C.	10.5%
Filler	14.5
Sand	75.5
	100.0%

The voids in the mineral aggregate would be from 23% to 26% depending on the sand grading, while the voids in the finished pavement should be as low as 1%, and not more than 4%.

Rock Asphalt

Specifications for this type usually call for grading requirements in the mineral aggregate and for the per cent of bitumen present in the mixture as laid. The material is usually prepared at the quarry, and spread and raked while cold. In general, such pavements resemble Sheet Asphalt, but as can readily be seen, the grading and bitumen content are less apt to be uniform in the Rock Asphalt, and therefore not as stable. At times it is necessary to add an Asphaltic Cement to the mixture in order to obtain one which contains sufficient bitumen to meet requirements. The general methods for construction are the same as for Sheet Asphalt, except that it is laid cold, and preferably at a temperature above 70° F.

Bituminous Macadam Surface Course (Penetration Method)

This pavement consists of a bottom course of broken stone of good quality, having a maximum size of 2½ inches, and is usually spread to a depth of four inches. After spreading, it is rolled until the maximum mechanical bond is obtained; care being taken that the stone is not crushed under the roller; after which a bituminous Binder is applied. Immediately following this application, intermediate sized stone is spread over the surface so as to fill all surface voids, and rolled; after which a seal-coat of bituminous material is applied, and a mineral covering is spread over the entire surface. Rolling is then resumed until the maximum compression is obtained.

The main points to watch in this construction, are, first, that segregation of coarse and fine stone particles does not occur; second, that a uniform application of the Bituminous material is made; and third, that the rolling is carried on in a careful and competent manner.

The penetration of the Asphaltic Cement usually ranges from 80 to 110, although it is used considerably harder in particularly warm climates.

Refined Tars are also used in this work, as a bituminous binder, but are considered inferior to Asphalt Cements.

Maintenance

It may be well to consider briefly at this point the maintenance of any of the above types.

In the Bituminous Concrete Surface Course cracks are quite unlikely to appear, except when there are contraction cracks in the foundation proper. Even then under warm weather traffic, the cracks may become closed without any serious defect resulting therefrom. Should the Seal-coat used on this type become worn, this can be repaired by using the same method as originally used. That is, by using an Asphalt Cement, or an Asphalt cut back with naphtha, and a mineral covering. This can be done to large and small areas at a relatively small cost. Where holes do appear in the Surface Course, the defective portion should be cut back to the full depth and replaced with the same material as used originally, if available. However, should this be impossible, the cold patch methods may be used with fairly good results.

In the Sheet types of pavement, which are apt to develop cracks due to contraction, or the use of too hard an Asphalt Cement, such defects may not be serious, and may be left without attention until the edges have worn away, when it should be cut back and replaced with fresh material. Rock Asphalt is also used in some sections for making repairs to this type of pavement.

In case that any type of pavement is subject to waves, or pushing as it is commonly called, the trouble is due to a faulty mixture, the use of too much Asphaltic Cement, or to the use of an Asphalt Cement having an excessively high penetration. This defect can be remedied only by taking up the whole area so affected.

Laboratory Control

The fulfilling of Specifications is so closely connected with efficient laboratory control, that it is thought advisable to discuss it in connection with the study of the Specifications.

Efficient laboratory control on bituminous construction is important in that it serves as an absolutely accurate check on the more or less accurate work of the inspector in the field. In other words, the testing and proportioning of the man in the field, while they may be done with the utmost care, are still subject to error due to conditions and environ-

(Continued on next page)

School *for* Inspectors *on* Asphalt Work

(Continued from page 3)

The supervision of the mixtures will be entirely under the control of the Division of Tests and Investigations. Daily records will be forwarded by the inspector on the plant and on the road to that office for tabulation and checking. The usual daily samples will be forwarded to the testing laboratory for analysis and a close check will be kept on all field operations.

The field supervision will be in charge of two construction engineers who will devote their entire time to perfecting the organization of each project carrying on this type of construction and they will be in close touch with all details governing the mixing and placing of the surface course.

These men will coordinate their work with the bituminous laboratory which will check test all samples tested by the field men and they will also be kept informed relative to the detail records kept daily in the Division office so that changes can be made quickly when necessary and the best work possible be secured.

The field supervision will be in charge of Mr. E. E. Strohm and Mr. E. R. Olbrich and the laboratory work is carried on under Mr. R. L. Oberholser. These men also are acting as instructors in the course being given and are thereby enabled to follow the progress of each student from the beginning. This will enable the inspectors who finish the course to be placed where they can function most efficiently.

The greater advantages of a course of this kind are that the men will be available when needed and an opportunity is provided to select the men who are capable of assuming the responsibility for this work when the proper supervision is maintained. The men are taken both with and without previous experience and are taught the methods and care in the work which will be required to maintain the high standard set for State Highway work. The supervisors, on the other hand, will not be hampered in the work for which they are held directly responsible by having to labor with the inspector who has been educated in methods other than those considered suitable by this department and cannot see the reason or importance of some of the details in the manipulation of bituminous mixtures as required by this department.

The plant and road inspectors will be held strictly responsible for the performance of all details of the specifications relating to the duties which are consigned to them and will not be allowed to make any changes unless authority is received from proper sources. The intent is to give intelligent inspection and to cooperate with the contractor to secure the best pavement which can be obtained under existing conditions. Reports are made from inspection of all parts of the construction and data are kept on record by the Division of Tests and Investigations regarding the progress made, the methods and materials used on each project and incidental summaries and comparisons of the different projects constructing the same type of pavement, so that while the records of one particular project might seem to be operated satisfactorily, a comparison with the records of another project operating under identical conditions might lead to an improvement being made.

Bituminous Specifications *and* Laboratory Control

(Continued from page 11)

ments. The well equipped Bituminous Laboratory, furthermore, has more and usually better testing equipment which, in the hands of experienced operators, make it an excellent court of final resort on work of this kind.

At the beginning of the work, the Inspector will submit preliminary samples of all materials, on which the Laboratory passes as to suitability, and the latter sets the formulae, which may arise, for the various mixtures, thus setting the field man right at the start of the work.

The control of proportioning in the field depends on the men that the Contractor employs and upon the calibre of the Inspector himself. The Laboratory knows no favorite, and in case the proportions are not within the limits set by the Engineer, the Inspector is immediately notified of his shortcomings and instructed as to how they may be remedied. Under our new Instructions, the Plant Inspector submits daily samples of the completed mixtures and of the Asphaltic Cement used, while the Road Inspector cuts from the finished pavement a sample for a density determination. These are properly identified by set forms as to location, et cetera, so as to avoid error. These samples are to be sent in to the Laboratory at the end of the day's work, so that they will reach their destination the next day, and that tests can be made by experienced men on that day. In case of error, the Inspector can then be notified of this by wire, so that only one day's time has elapsed since the time of error until correction is made. This is the closest possible check and insures absolute accuracy in all details of proportioning.

In the case of Asphaltic Cement, the Inspector in the field makes his test on the same sample that he submits to the Laboratory, at the same time noting his penetration on his report. This system takes care of the Asphalt Cement, as regards consistency, each day.

The Extraction Test on Bituminous Concrete and Sheet Asphalt Wearing Surface will show exactly the per cent of Asphalt, Filler, Sand and Stone in the mixture produced at the plant and the grading of the different aggregates. This in itself is a check on the proportioning and on the Inspector's daily testing work, and shows whether or not the materials used are consistent with the submitted samples.

From the Road Sample of compressed pavement, the Laboratory will determine the density of the completed pavement. This test will show whether or not the maximum compression has been obtained, or if it has, if the mixture can be improved upon to give a smaller percentage of voids. It is even possible by laboratory test to determine the effect of excessive heat on the Asphaltic Cement, by extracting the bitumen, penetrating it and running a ductility determination on it, which will show whether the Asphalt has been injured by hardening, due to the exposure to excessively high temperatures.

The two most important qualifications of an Asphalt Pavement are Density and Stability. Through Density the pavement is rendered waterproof, thereby prolonging the life of the pavement by preventing absorption, which will rot the bitumen in time; and by the firm retention of all of the smaller particles of aggregate in the mixture under traffic.

Through Stability, the pavement is made less liable to displacement in a manner known as pushing or waving, which movement is indicative of the fact that the pavement, as a structure, is a failure.

These two major points are assured with competent laboratory control and inspection.

STATUS OF FEDERAL AID WORK IN NORTH CAROLINA

Projects Under Construction

"H S" denotes any type of hard surfaced road. "G" denotes any type of gravel, sand-clay, or topsoil road.

NO.	COUNTY	LENGTH	TYPE	APPROXIMATECOST	BEGUN	CONTRACTOR
4	Craven	9.46	G	$ 21,089.23	10–12–19	County Commissioners
13	Wayne	12.573	G	101,467.23	5–25–20	County Commissioners
15	Guilford	4.205	H S	5,441.75	9- 1–17	County Commissioners
16	Haywood	14.27	G	64,705.05	7–26–19	County Commissioners
17	Wilkes	17.6	G	101,386.08	10–15–18	County Commissioners
49	Lenoir	6.017	H S	199,872.19	2- 9–20	T. H. Gill & Company—West Construction Co.
53	Lenoir	7.234	H S	246,838.20	7- 6–20	T. H. Gill & Company—West Construction Co.
58	Johnston	6.018	G	69,453.50	5–20–20	P. R. Ashby
60	Lenoir	7.88	H S	259,445.25	12–23–19	T. H. Gill & Company—West Construction Co.
61	New Hanover	2.186	G	234,841.39	7–12–20	C. W. Lacy
66	Haywood	6.18	G	105,296.45	9–15–20	O'Brien Construction Co.
68	Sampson-Harnett	27.4	G	305,225.54	7–23–20	P. R. Ashby—F. L. Grant, Inc.
69	Transylvania	9.348	G	231,409.04	3–25–20	Allport & Alexander Construction Company
70A	Jackson	4.83	G	150,081.11	6–18–20	Wright & Nave
73	Nash	8.73	G	159,913.16	1–20–21	Porter & Boyd
75	Columbus	7.06	G	66,605.38	12- 9–20	County Commissioners
86A	Martin-Bertie	3.09	G	98,454.67	2–25–20	State Forces (Road)
86B	Martin-Bertie	.....	Bridges	332,308.83	3–19–21	Boyle-Robertson Construction Co.
90	Pamlico	12.03	G	127,981.78	1- 2–21	Eagle Engineering Company
93	Franklin-Warren	19.8	G	192,993.57	9–25–20	Chandler & Ragland—Stearns Bros.
94A	Mitchell	5.04	H S	190,375.13	6–22–20	Gibson Construction Company
96	Yancey	2.95	G	82,653.12	1- 3–21	Gibson Construction Company
98A	Moore	20.53	G	259,240.38	9–10–20	J. T. Plott—J. E. Lane & Co.
98B	Moore	8.75	G	41,055.46	6- 6–21	Lee J. Smith Construction Co.
99B	Chatham	21·82	G	259,931.59	11–19–20	J. T. Plott—Atlantic Bridge Co. (Bridges)
101B	Randolph	9.64	G	107,928.75	11- 5–20	J. T. Plott—Hanford Bros. (Bridges).
103	Duplin	11.32	G	111,931.05	6–10–20	County Commissioners
117	Wilson	6.25	G	41,828.93	3- 8–21	County Commissioners—Lee J. Smith (Bridges)
120	Bladen	23.67	G	105,688.55	2–16–21	J. A. Marrow—P. R- Ashby (Bridges)
125A	Alleghany	4.99	G	153,899.13	11–22–21	W. E. Graham
127	Wilson	7.63	G	33,780.45	3- 5–21	County Commissioners—Lee J. Smith (Bridges)
136	Davie	6.99	G	61,733.04	2–14–21	Chandler & Ragland—Hagedorn Const. Co. (Bridges)

Projects Completed

NO.	COUNTY	LENGTH	TYPE	APPROXIMATECOST	COMPLETED	CONTRACTOR
1*	Mecklenburg	.....	Bridge	$ 59,224.90	9- 5–18	C. W. Requarth & Company
2*	Henderson	7.75	G	33,141.74	12–17–19	State Convict Labor
3*	McDowell	2.85	G	24,405.73	12–17–19	County Commissioners
5*	Burke	8.03	G	19,888.05	11- 1–19	County Commissioners
8*	Cumberland	13.46	G	62,800.71	6–20–21	County Commissioners
9*	Polk	12.78	G	68,175.45	4–15–21	County Commissioners
11*	Lenoir	1.78	H S	56,893.18	1–25–21	West Construction Company
12*	Wayne	8.62	G	26,727.98	11- 2–20	County Commissioners
14*	Halifax	8.01	G	19,017.83	8–20–19	State Convict Labor
18*	Alexander	9.8	G	66,446.49	3–31–21	County Commissioners
19*	Rockingham	8.21	G	32,759.36	11–11–19	County Commissioners
20*	Yadkin	6.41	G	25,146.45	7–26–20	County Commissioners
21*	Person	7.675	G	25,911.04	3–15–20	County Commissioners
22A*	Alamance	1.196	H S	30,103.48	6–27–19	County Commissioners
22B*	Alamance	8.3	H S	290,179.36	8–19–21	Powell Paving and Construction Company
23*	Burke	7.68	G	42,873.90	11- 1–20	Lovelady Township Forces
24*	Wake	4.24	H S	127,840.21	11–30–19	W. W. Boxley & Company
25*	Person	8.175	G	101,537.51	10–20–20	County Commissioners
26*	Davidson	8.41	G	14,115.96	10- 1–19	County Commissioners
27A	Orange	8.235	G	53,945.73	4–23–21	W. S. & L. A. Crawford
29*	Union	8.655	G	58,949.25	4- 8–21	County Commissioners—J. S. Stearns
30	Mecklenburg	6.304	H S	102,551.35	3–31–21	County Commissioners
31*	Buncombe	3.1	H S	70,174.88	10–24–19	County Commissioners
33	Montgomery	3.72	G	15,246.71	6- 8–21	County Commissioners
34	Wayne	.....	Bridge	50,798.00	10- 8–21	Roanoke Bridge and Iron Works, Inc.
35*	Forsyth	1.87	H S	59,867.61	2–25–20	County Commissioners
36*	Durham	3.46	H S	115,075.57	12–15–19	R. G. Lassiter & Company
37	Gaston	10.38	H S	167,173.23	12–28–21	County Commissioners
38*	Rockingham	10.92	G	46,809.92	9–17–20	County Commissioners
38A	Caswell	6.67	G	50,907.23	7- 6–21	Bolton Construction Co.
39	Union	10.61	G	74,337.71	4- 9–21	County Commissioners—J. S. Stearns
40*	Union	4.287	G	18,434.20	12–11–20	County Commissioners
41	Watauga	8.95	G	94,681.29	11–10–21	County Commissioners
42*	Stanly	11.67	G	80,922.15	9–10–20	Gibson Construction Company
43*	Beaufort	2.2	H S	95,089.12	5–11–20	Simmons Construction Company
44*	Granville	4.57	G	51,377.43	4–20–21	T. W. Chandler—P. R. Ashby
45	Buncombe	7.852	H S	359,777.28	7–23–21	H. A. Wells-Asheville Const. Co.—Asheville Paving Company
47*	Guilford	4.607	H S	162,689.83	4- 8–21	County Commissioners
48A*	Northampton	5.804	G	60,620.51	10–30–20	Virginia Contracting Company
48B	Northampton	2.69	G	44,749.65	10- 4–20	Porter & Peck–A. C. House
50*	Guilford	2.65	H S	101,596.44	12–31–20	County Commissioners

(Continued on next page)

STATUS OF FEDERAL AID WORK IN NORTH CAROLINA---*Continued*

Projects Completed (Continued)

NO.	COUNTY	LENGTH	TYPE	APPROXIMATE COST	COMPLETED	CONTRACTOR
51	Guilford	2.26	H S	87,603.12	9–27–20	County Commissioners
52	Cabarrus	8.986	G	162,399.61	3–22–21	Gibson Construction Co.—J. E. Lane
54*	Wake	6.811	H S	239,736.26	8–23–20	R. G. Lassiter & Company
55A*	Mecklenburg	6.008	H S	196,899.73	12–28–20	Simmons Construction Company, Inc.
55B	Mecklenburg	4.59	H S	188,445.18	8–13–21	Simmons Construction Co., Inc.
56*	Forsyth	5.868	G	47,709.31	10–29–20	C. B. Hester-Luten Bridge Company
57	Rowan	6.75	G	72,549.27	4–22–21	W. E. Graham—R. M. Hudson Company
59	Columbus	11.025	G	106,872.26	1–26–22	County Commissioners
62	Buncombe	3.43	H S	139,191.32	11– –21	H. C. McCrary, Inc.—Asheville Construction Co.
63	Buncombe	3.76	H S	167,933.55	9–20–21	Allport & Alexander Construction Co.—H. C. McCrary, Inc.—Asheville Paving Company
65	Pitt	9.57	G	99,181.06	10–20–21	Porter & Peck
67*	Nash	8.81	H S	384,126.08	4–20–21	R. G. Lassiter—Atlantic Bridge Company
71	Durham	6.69	H S	319,153.39	10–26–21	State Forces
72*	Anson	3.896	G	70,470.89	3– 4–21	Gibson Construction Co.—J. A. Kreis & Co.
74A*	Stanly	2.803	G	25,537.45	8–20–20	County Commissioners
74B	Stanly	4.92	G	63,411.26	5– –21	County Commissioners
76*	Cabarrus	1.35	H S	54,583.76	10–29–20	R. M. Hudson & Company
77	Rutherford	2.206	H S	100,159.44	9– 5–21	E. T. Belote
78A	Rutherford	9.64	G	88,230.71	8– 3–21	Ross Brothers.
78B	Rutherford	10.26	G	71,056.48	8– 3–21	Ralph E. Oliver
79*	Cleveland	1.645	H S	67,063.64	10–30–20	Noll Construction Company
80A	Montgomery	16.6	G	226,516.20	6–20–21	County Commissioners
80B	Montgomery	11.07	G	65,145.02	10–25–21	Lee J. Smith Const. Co.—P. R. Ashby
81	Pender	26.11	G	273,439.45	12– –21	Porter & Boyd
82	Davidson	4.54	G	59,983.71	12–18–20	Heilig & Sherrill
84A	Burke-McDowell	8.33	G	128,193.76	8– 3–21	J. A. Kreis & Company
84B	McDowell	6.76	G	109,659.49	8– 1–21	J. A. Kreis & Company
85*	Davie	8.28	G	58,756.89	9–26–20	W. E. Graham
91	Surry	10.68	G	113,805.84	6–27–21	W. E. Graham—R. W. Curtis & Co.
92	Surry	10.83	G	133,141.03	6–20–21	W. E. Graham—R. W. Curtis & Co.
98C	Lee	4.53	G	18,240.64	10–29–21	Gibson Construction Co.
99A	Chatham	12.65	G	126,717.70	8–11–21	T. W. Chandler—State Forces (Bridges)
100	Avery	14.00	H S	272,089.78	11– –21	Southern Dray Company
101A	Randolph	10.04	G	123,893.99	8–12–21	S. L. Davis—J. A. Kreis & Co. (Bridges)
105	Hoke	9.8	G	95,501.80	10–25–21	Jameson Brothers—George, Hankins & George
107	Madison	2.46	G	70,910.40	10– –21	Southern Dray Company
109	Burke	3.58	G	55,191.64	5–21–21	C. E. Teague
111	Forsyth	12.22	G	94,447.10	8–17–21	C. B. Hester—Heilig & Sherrill
112	Caswell	11.93	G	147,065.71	11– 2–21	J. M. Gregory—J. E. Lane & Co. (Bridges).
114*	Rowan	2.543	H S	83,587.02	3–17–21	R. M. Hudson & Company
116	Stanley-Montgom'	.....	Bridge	199,614.80	1– 9–22	Cornell-Young Company
121	Stokes	11.60	G	108,519.62	1–14–22	Jameson Bros.—Rogers & Shumway (Bridges)
129	Richmond	17.28	G	77,507.48	12– –21	Mulligan & Roach

*Final Settlement Made With Federal Government

STATUS OF STATE AID WORK IN NORTH CAROLINA

Projects Under Construction

"H S" denotes any type hard surfaced road. "G" denotes any type of gravel, sand clay, or topsoil road.

NO.	COUNTY	LENGTH	TYPE	APPROXIMATE COST	BEGUN	CONTRACTOR
100	Beaufort	10.50	H S	$ 369,777.70	8–23–21	W. T. Hadlow.
114	Chowan	10.00	G	45,064.09	1– 4–22	Battershill & Goode—Chandler & Ragland.
137	Halifax	5.67	H S	124,736.97	10–31–21	O. F. Leighton—A. C. House
139	Halifax		Bridge.	18,436.66	10–11–21	Chandler & Ragland—Porter & Peck.
151	Hyde	4.30	G	71,422.78	12–10–21	C. W. Lacy—Porter & Peck.
155	Martin-Pitt	20.00	G	98,176.65	1–12–22	J. P. Dicus—P. R. Ashby.
160	Franklin-Wake-Nash	9.83	G	53,722.95	12– 7–21	Chandler & Ragland—Southern Dray Co.
175	Pasquotank	9.50	H S	217,405.72	4– 6–21	County Commissioners.
186	Pitt	9.57	H S	260,816.60	9–20–21	Cheatwood & Driscoll.
191	Tyrell	6.91	G	57,934.41	1–20–22	C. W. Lacy—M. M. Jones.
209	Craven	2.65	H S	115,688.21	8–00–21	Eagle Engineering Co.
218	Wayne-Duplin	16.06	G	80,804.50	8– 4–21	C. W. Lacy
227	Greene	6.81	H S	238,113.70	12–19–21	West Const. Co.—Union Paving Co.
280	Wayne	10.01	H S	311,352.36	11–28–21	Union Paving Company
281	Wayne	.....	Bridge	22,484.88		P. R. Ashby
301	Bladen	13.17	G	82,028 21	11–12–21	J. F. Mulligan–Powell Paving & Cont Co.
325	Columbus	11·22	G	105,258.23	11– 3–21	J. A. Kreis–Cornell–Young Co.
338	Cumberland–Sampson	.....	Bridge	26,233.99	10–28–21	Roanoke Bridge & Iron Works.
339	Harnett-Cumb l'nd	.....	Bridge	16,524.75	11–30–21	Porter & Boyd
375	Pender	15.56	G	72,522.92	11– 1–21	A. W. McClay.
376	Pender	7.64	G	94,757.85	11–11–21	C. G. Kershaw Const. Co.—Cornell Young Co.
388	Robeson	3.35	H S	137.009.40	11–10–21	C. W Lacy—Roanoke Bridge & Iron Works.
389	Roberson–Colum.	1.56	G	83,463.38	10–26–21	L. A. Chitwood.
411	Durham	5.81	H S	211,574.92	9– 1–21	Hutton Eng. & Const. Co.

(Continued on next page)

STATUS OF STATE AID WORK IN NORTH CAROLINA---*Continued*

Projects Under Construction (Continued)

NO.	COUNTY	LENGTH	TYPE	APPROXIMATE COST	BEGUN	CONTRACTOR
427	Granville	5.12	H S	$ 159,097.62	12- 1-21	R. G. Lassiter & Co.
436	Harnett	21.19	G	144,318.14	6-28-21	C. G. Kershaw Const. Co.—Hobbs & Kitchen.
454	Orange	4.29	H S	192,006.15	6-18-21	Elliott, Sholes & Teer
455	Orange	4.19	G	46,415.77	11-28-21	J. F. Mulligan Const. Co.—P. R. Ashby.
456	Orange	9.00	G	37,459.07	1- 7-22	Crawford & Crawford—Nello Teer.
482	Wake	6.64	H S	191,669.21	12- 8-21	R. M. Hudson Company.
501	Alamance	13.10	G	32,627.10	12- 7-21	W. M. Shook—Hanford Bros.
511	Caswell	14.8	G	74,192.58	12-12-21	White & Simpson—C. B. Hester.
525	Davidson	10.24	H S	363,141.68	12-23-21	Elliott & Sons & Boggs—Austin Bros. Bridge Co.
533	Guilford-Forsyth	10.59	H S	427,997.62	7-11-21	Royer-Ferguson Const. Co.
630	Gaston	3.02	H S	98,392.36	10-12-21	W. F. McCanless.
632	Gaston	9.5	H S	291,868.94	1—2-22	Davis-Wilcox Const. Co.
638	Iredell	7.88	H S	244,509.30	10-12-21	Thompson-Caldwell Co.
639	Iredell	10.59	H S	387,448.42	1—2-22	R. M. Hudson Co.—Luten Bridge Co.
655	Mecklenburg	1.57	H S	62,027.68	12-21-21	Speed-Parker Co., Inc.—Luten Bridge Co.
657	Mecklenburg	13.8	G*	20,000.00	12- 8-21	State Forces.
700	Alleghany	7.90	G	132,297.33	6-23-21	W. E. Graham
701	Alleghany-Wilkes	8.00	G	153,863.60	6-16-21	W. E. Graham
710	Ashe	3.14	H S	142,687.93	9- 8-21	Pittman Const. Co.
725	Caldwell	2.4	G*	10,000.00	12-29-21	County Commissioners.
750	Stokes	14.86	G	93,054.48	9-15-21	J. F. Mulligan Const. Co.—Lee J. Smith
751	Stokes	7.25	G	31,746.00	10- 4-21	W. E. Graham
780	Wilkes	18.00	G*	25,000.00	7-25-21	J. F. Mulligan.
781	Wilkes	14.50	G*	30,000.00	7-25-21	J. F. Mulligan.
783	Wilkes-Watauga	34.40	G*	80,000.00	9- 2-21	Chandler & Ragland.
811	Burke	6.0	H S	189,412.41	1-13-22	Southern Dray Company.
823	Cleveland	2.0	H S	81,234.01	1—2-22	Southern Paving Co.—Z. B. Weathers & Son.
844	McDowell	1.80	H S	57,048.42	5-12-21	Bolton Construction Co.
845	McDowell	7.19	G	132,177.93	9- 6-21	J. W. Stapp Const. Co.—Praytor, Howton Wood Const. Co.
846	McDowell	10.06	G	204,680.74	9-12-21	Asheville Const. Co.—W. T. Taylor Const. Co.
855	Mitchell	4.97	H S	174,393.78	9-12-21	Fiske-Carter Construction Co.
877	Rutherford	9.79	G	64,563.73	5-31-21	Geer & Wilson
878	Rutherford	6.55	G	50,913.50	9-22-21	Michaux Const. Co.—Geer & Wilson.
879	Rutherford	.....	Bridge	5,737.38	1—9-22	Austin Bros. Bridge Co.
910	Cherokee	7.56	G	76,743.59	5-24-21	Ross Bros.—W. T. Moore Conc. Prod. Co.
911	Cherokee	10.33	G	84,475.38	10-25-21	H. A. Wells—Southern Dray Co.
920	Clay	4.8	G	54,875.81	1—9-22	E. A. Wilson & Co.—W. T. Moore Conc. Prod. Co.
921	Clay	12.37	G	123,929.52	10-24-21	Lee J. Smith Const. Co.—W. T. Moore Conc. Prod. Co.
930	Graham	12.90	G	130,522.00	10-15-21	Lee J. Smith Const. Co., C. M. Dicus.
942	Haywood	0.57	G	5,294.46	7-12-21	O'Brien Construction Co.
950	Jackson	7.56	G	145,313.30	6-13-21	Wright & Nave—O'Brien Const. Co.
960	Macon	4.97	G	69,100.57	6- 6-21	J. T. Plott—J. E. Lane & Co.
961	Macon	4.77	G	58,340.59	12- 5-21	J. T. Plott—J. E. Lane & Co.
970	Madison-Yancey	13.80	G	267,378.26	10-11-21	R. H. Wright & Sons—O'Brien Const. Co.

Projects Completed

500	Alamance	5.22	G	32,732.20	1-17-22	W. W. Tuck & Son—A. M. Hazell, Connerate—Quist Const. Co
692	Union	2.28	H S	65,366.67	12-28-21	Redmon Construction Co.
722	Caldwell	7.00	G*	12,000.00	1-18-22	County Forces.

*Reconstruction only.

Projects Under Contract

NO.	COUNTY	LENGTH	TYPE	APPROXIMATE COST	CONTRACTOR
113	Chowan	10.32	G	40,759.73	Nello L. Teer—P. R. Ashby.
159	Nash	11.22	G	89,942.43	J. A. Kreis & Co.
211	Craven	9.93	H S	262,673.20	Union Paving Company.
245	Jones	15.76	H S	244,737.90	Hyde & Baxter
263	Pamlico	12.03	H S	289,324.20	Union Paving Company.
291	Wilson	7.63	H S	203,493.18	P. R. Ashby.
409	Durham	0.5	H S	6,140.64	J. P. Dicus.
410	Durham	2.3	H S	83,921.97	C. D. Riggsbee.
481	Wake	7.20	H S	252,925.15	Union Paving Co.—P. R. Ashby.
483	Wake	0.54	H S	19,989.75	C. D. Riggsbee.
504	Alamance	5.22	H S	154,127.16	Elliott-Sholes Company.
532	Guilford	11.70	H S	387,499.20	Elliott-Sholes Company.
622	Catawba	10.85	H S	354,684.88	Union Paving Company.
653	Mecklenburg	8.84	H S	308,182.44	Union Paving Co.—Luten Bridge Co.
695	Union	4.3	H S	123,865.28	Redmon Const. Co.
782	Wilkes	5.97	H S	184,614.65	Hyde & Baxter
833	Henderson	15.90	G	38,412.44	S. L. Davis Const. Co.—Asheville Const. Co.
856	Mitchell	4.0	H S	239,005.80	Porter & Boyd—L. J. Chandler & Co.
980	Macon-Swain	17.9	G	344,161.29	E. A. Wilson & Co.—Southern Dray Co.

(Continued on next page)

STATUS OF STATE AID WORK IN NORTH CAROLINA---*Continued*

Summary

	NUMBER OF PROJECTS			MILEAGE		APPROXIMATE TOTAL COST		
	H S	G	BRIDGE	H S	G	H S	G	BRIDGE
UNDER CONSTRUCTION								
Federal Aid Projects	5	26	1	30.38	285.12	$ 901,972.52	$3,290,573.63	$ 332,308.83
State Aid Projects	24	39	5	151.22	399.54	5,049,411.11	3,224,439.42	89,417.66
Total Under Construction	29	65	6	181.60	684.66	5,951,383.63	6,515,013.05	421,726.49
UNDER CONTRACT								
Construction not yet begun								
Federal Aid Projects								
State Aid Projects	15	4		106.77	55.34	3,115,185.40	513,275.89	
Total Under Contract	15	4		106.77	55.34	3,115,185.40	513,275.89	
COMPLETED								
Federal Aid Projects	26	55	3	122.05	477.68	4,039,583.81	4,107,985.75	309,637.70
State Aid Projects	1	2		2.28	12.22	65,366.67	44,732.20	
Total Completed	27	57	3	124.33	489.90	4,104,950.48	4,152,717.95	309,637.70

Total mileage of Hard Surface work under construction or contracted for	288.37
Total mileage of Topsoil, Sand Clay or Gravel work under construction or contracted for	740.00
Total mileage under construction or contracted for	1,028.37

Total cost of Hard Surface work under construction or contracted for	$ 9,066,569.03
Total cost of Topsoil, Sand Clay or Gravel work under construction or contracted for	7,028,288.94
Total cost of Bridge work under construction or contracted for	421,726.49
Grand Total cost of work under construction or contracted for	$ 16,516,584.46

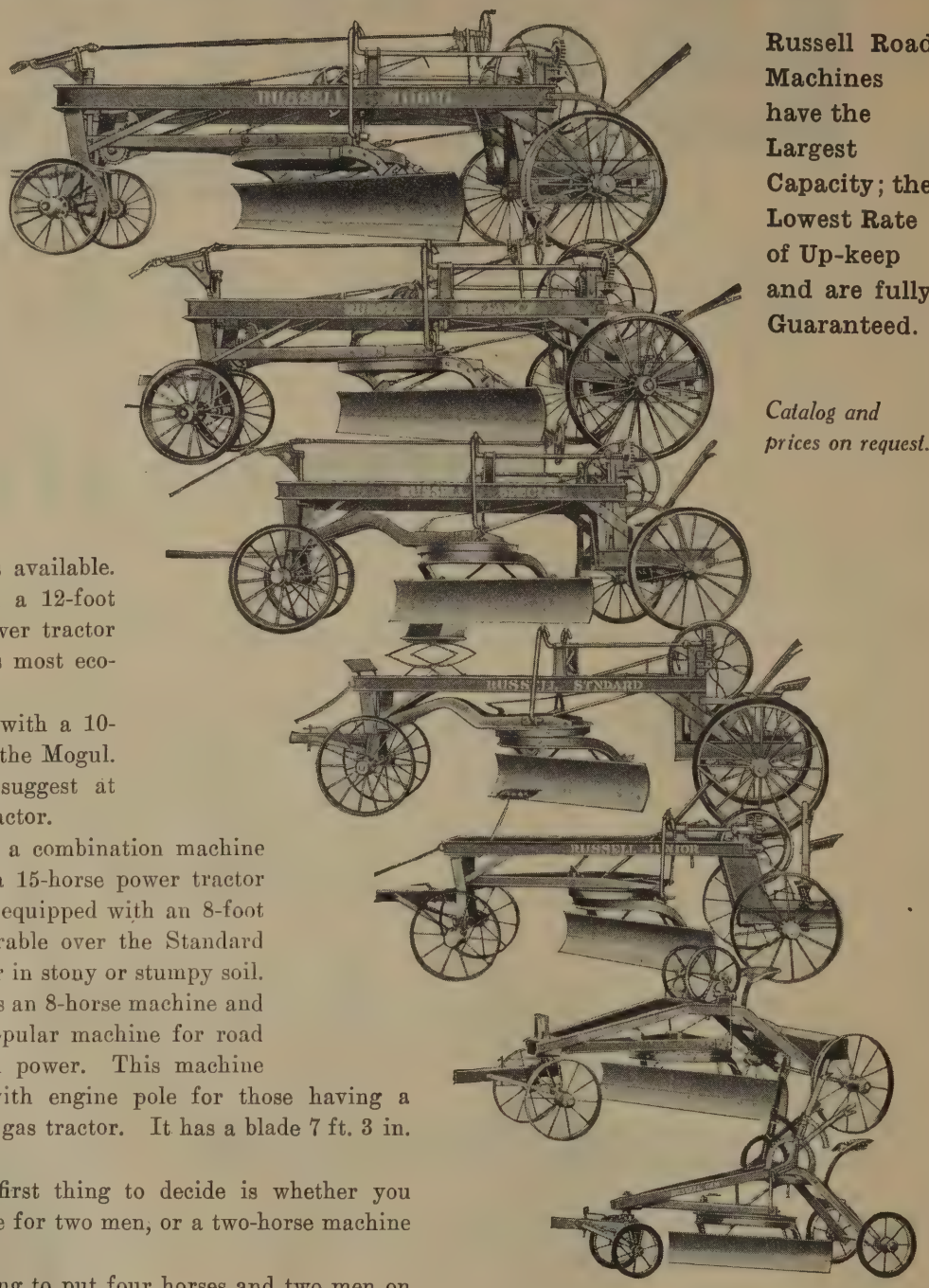
Total mileage of Hard Surface work completed	124.33
Total mileage of Topsoil, Sand Clay or Gravel work completed	489.90
Total mileage of work completed	614.23

Total cost of Hard Surface work completed	$ 4,104,950.48
Total cost of Topsoil, Sand Clay, or Gravel work completed	4,152,717.95
Total cost of Bridge work completed	309,637.70
Grand Total of all work completed	$ 8,567,306.13

Corrected to February 1, 1922

A Russell Road Machine for Every Need

Before deciding upon a road machine let us assist you by suggesting what we consider best for your requirements. We make this offer because we know that this is one of your problems. The first thing to decide upon is whether you want a machine for construction or maintenance; for horse power or tractor power.



Russell Road Machines have the Largest Capacity; the Lowest Rate of Up-keep and are fully Guaranteed.

Catalog and prices on request.

For Construction buy the largest machine for which power is available. The *Russell Mogul* with a 12-foot blade and a 25-horse power tractor will construct your roads most economically.

The *Russell Reliance,* with a 10-foot blade, ranks next to the Mogul. With this machine we suggest at least a 20-horse power tractor.

The *Russell Special* is a combination machine for which you may use a 15-horse power tractor or 8 or 12 horses. It is equipped with an 8-foot blade and is often preferable over the Standard for use with animal power in stony or stumpy soil.

The *Russell Standard* is an 8-horse machine and is, no doubt, the most popular machine for road construction with animal power. This machine may also be equipped with engine pole for those having a small 8 to 15-horse power gas tractor. It has a blade 7 ft. 3 in. long.

For Maintenance the first thing to decide is whether you want a four-horse machine for two men, or a two-horse machine for one man.

For those who are willing to put four horses and two men on the grader, the *Russell Junior* will do maintaining work more effectively than any other grader. This machine has a 6-foot blade and may be used for light road construction as well as maintenance.

The *Russell Hi-Way Patrol* grader is built especially for greatest efficiency in patrol and maintenance work with two horses and one man. It is lighter than the Junior and is equipped with a 6-foot blade. Blade is operated by worm and gear lift, giving the finest kind of adjustment.

The *Russell Gem* is the cheapest of the high-framed type machines. It is equipped with 5-foot, one-piece, reversible blade. The blade is operated by lever. It is a one-man, two-horse machine.

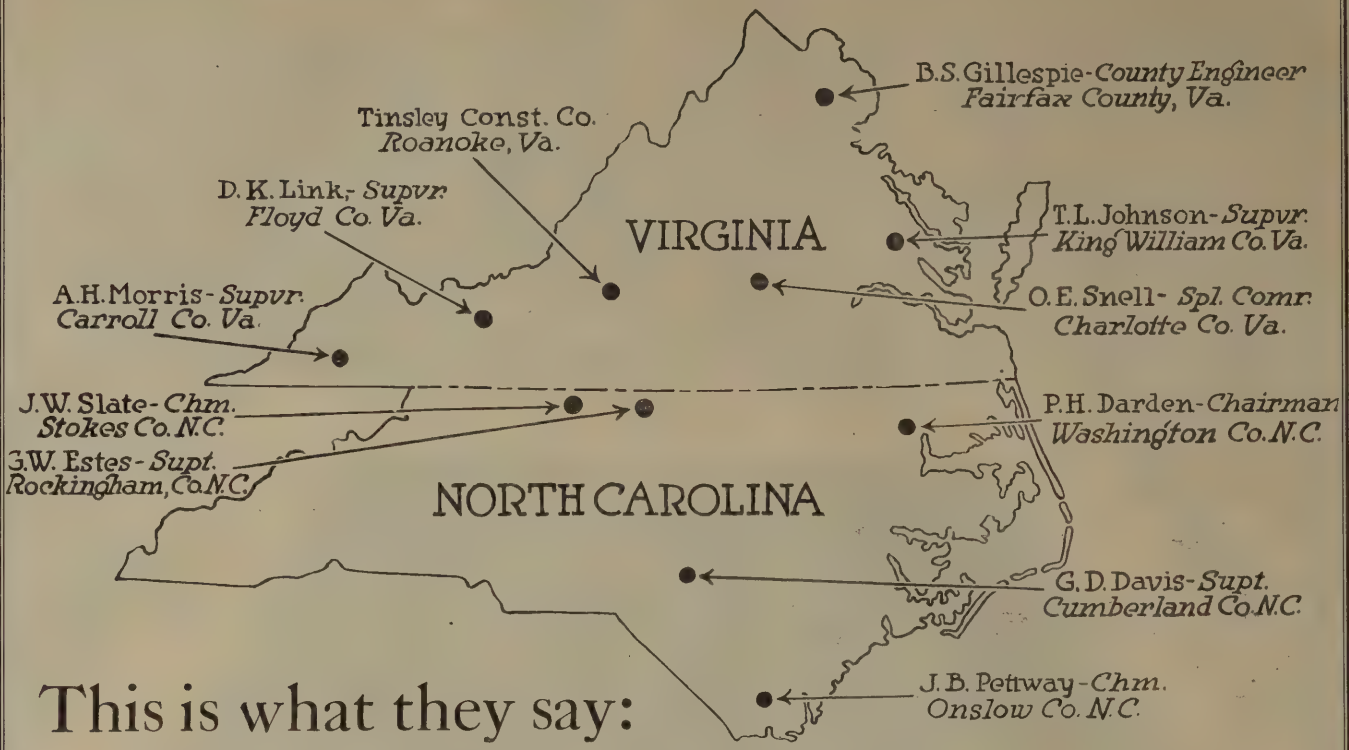
E. F. CRAVEN,

"THE ROAD MACHINERY MAN"
GREENSBORO, NORTH CAROLINA

STATE DISTRIBUTOR

COMPLETE LINE OF MACHINES AND REPAIRS IN STOCK

Here's Where they are Located:



This is what they say:

"We believe the HOLT "CATERPILLAR" Tractor to be the best possible method for building and maintaining Roads."

We believe the HOLT "CATERPILLAR" Tractor to be the cheapest possible method for building and maintaining Roads."

We believe the HOLT "CATERPILLAR" Tractor will give the best possible satisfaction in building and maintaining Roads."

There's lots of "history" connected with this:

Fairfax County bought their first "five" sometime ago and have added a "ten."

After the first purchase additional "CATERPILLARS" have been added by Charlotte and Floyd Counties, Virginia, and Washington, Cumberland and Rockingham Counties, North Carolina.

This tells the whole story!

THERE'S BUT ONE **"CATERPILLAR"** HOLT BUILDS IT

Have you placed an order for yours? If not communicate with

TRACTOR & MACHINERY SALES COMPANY

1631 WEST BROAD STREET, RICHMOND, VA.

DISTRIBUTORS

THE AUSTIN-WESTERN ROAD MACHINERY CO.
THE HOLT MANUFACTURING COMPANY
BAKER-MANEY WHEELER

Fort Fisher Highway, New Hanover Co., N. C. Treated with "Tarvia-B" 1915-17-18-19 and "Tarvia-A" in 1916.

Above is Wrightsville Turnpike, New Hanover Co., N. C. Treated with "Tarvia-A" 1915, and with "Tarvia-B" 1917.

Another view of Fort Fisher Highway.

"The Best Investment The Board Ever Made"

Mr. Addison Hewlett, Chairman of the Board of Commissioners of New Hanover County, N. C., writes, under date of July 25, 1921:

"We have been using Tarvia for surface treating the macadam roads of New Hanover County for the past six years, and we find this treatment satisfactory in every respect.

"Before we started the use of Tarvia we had great difficulty in maintaining our roads, as they became very dusty in dry weather and washed away in wet weather, leaving our road surface full of holes and ruts. Since using Tarvia the surface of the roads has been well protected in all kinds of weather, and today our roads have smooth, hard surfaces and our maintenance problem has been very easily solved. The Tarvia treatment is very inexpensive.

"It is unquestionably the best investment the Board of Commissioners has ever made and the Commissioners would not consider for a moment discontinuing Tarvia on our roads."

Tarvia
For Road Construction Repair and Maintenance

Additional comments on Tarvia are made by R.. A. Burnett, County Superintendent of Roads:

"Tarvia treatments are given to some of our roads every year while other roads, such as the Wrightsville Turnpike, have lasted as long as three years before requiring another treatment.

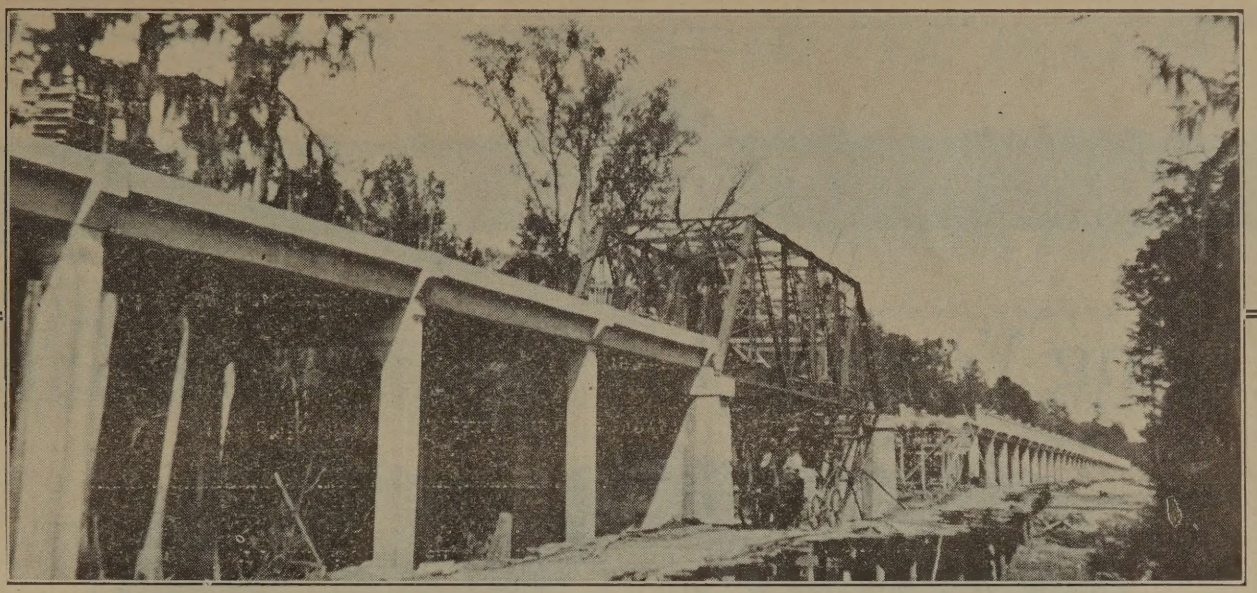
"These treatments have cost us in the neighborhood of $300 per mile per year and have proved to be the best, easiest and cheapest method of maintaining our roads. We have always had the best of co-operation from your engineers . . .

"We feel that we have a finer system of roads than any other county in the State."

No matter what your road problems may be—new construction, maintenance, or repairs—there is a grade of Tarvia made especially for the purpose.

Write for free illustrated booklet describing the various uses of Tarvia

36th and Grey's Ferry Avenue The Barrett Company **Branches in All Leading Cities** TRADE B MARK **PHILADELPHIA, PA.**



Oconee River Bridge (Fed. Aid Pro. No. 8) opened to traffic Oct. 21, 1921. Built by C. T. Dawkins Construction Co., (Jacksonville, Fla.) from designs by Garrett & Slack, consulting engineers (Montgomery, Ala.)

The longest and largest bridge In the Eighth Federal District

was built with

"ENSLEY" & "ALA CITY" BASIC SLAG CRUSHED & SCREENED

Georgia and her State Highway Department are to be congratulated on adding to the permanent highways of the state so magnificient a structure as this huge Slag concrete bridge that spans the Oconee river near Mt. Vernon, Ga.

No finer tribute to Slag, or to the service furnished by Slag Headquarters, can be found than the accompanying letter (dated Nov. 12, 1921) from the President of the Dawkins Construction Co.—builders of the Oconee bridge.

"Our hats are off to Ensley Basic Slag because it was there when we needed it in the construction of the longest Federal Aid Bridge in the entire Eighth Federal District (comprising the six Southeastern states.) When we started this work price and quality were the deciding factors, and we placed our business with you after making careful tests of the quality of your product. Slag had not been approved for concrete roadways then and the Federal and State engineers had to be shown. After these tests, Slag was approved and has been used right on.

"When conditions changed, so that service took the place of price in importance, we kept right on doing business with you.

"This job took 4000 tons of Slag for the concrete. The 54 spans of 35 ft. each are of the standard girder design and will hold up a moving load of 30 tons. Some of the column foundations are 50 ft. tall and go down 30 ft. below ground to rest on rock. The Oconee bridge is 2378 ft. between abutments. Total length, including embankment approaches, is 3187 ft. It has three 100-ft. steel spans and one 180-ft. steel draw span.

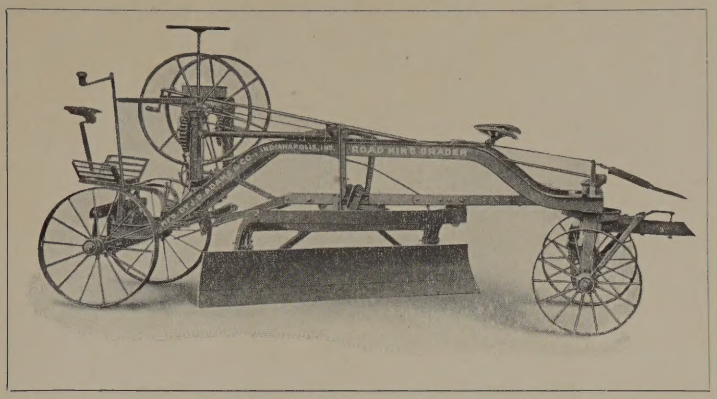
"We consider the construction of Ga. Fed. Aid Proj. 8, the bridge over the Oconee river near Mt. Vernon, as one of our worthwhile contributions to the public highways of the South, and one that eminently justified all of the effort we put into it to carry it to successful completion.

BIRMINGHAM SLAG COMPANY

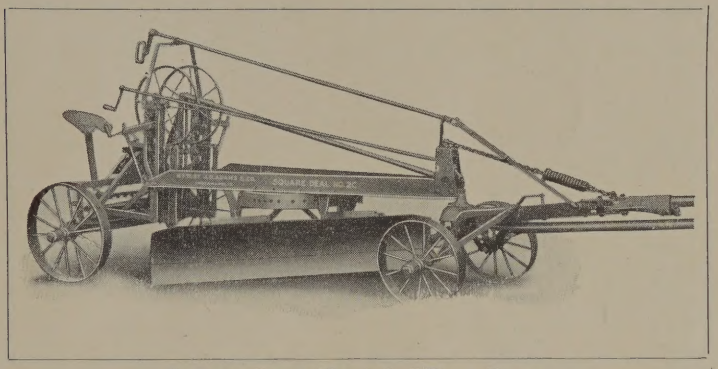
"Slag Headquarters for the South"

ATLANTA BIRMINGHAM THOMASVILLE

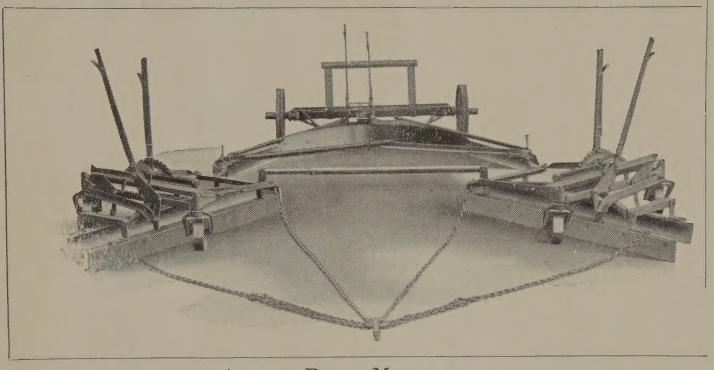
MOST MILES OF GOOD ROADS PER DOLLAR



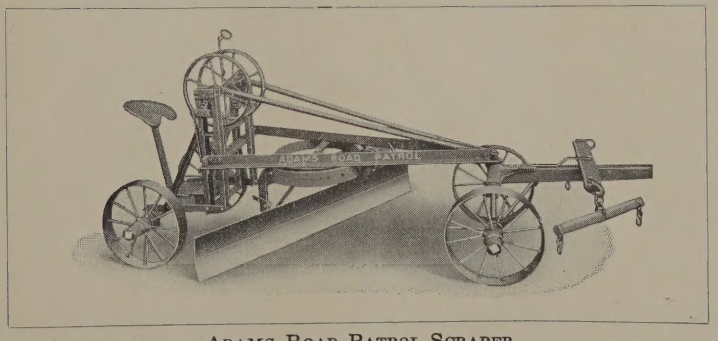
ROAD KING GRADER, 8-FOOT BLADE



SQUARE DEAL NO. 2-C, 7-FOOT BLADE



ADAMS ROAD MAINTAINER



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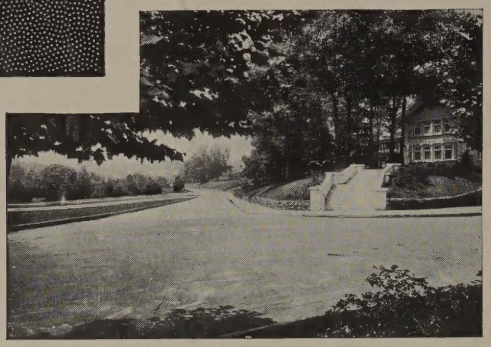
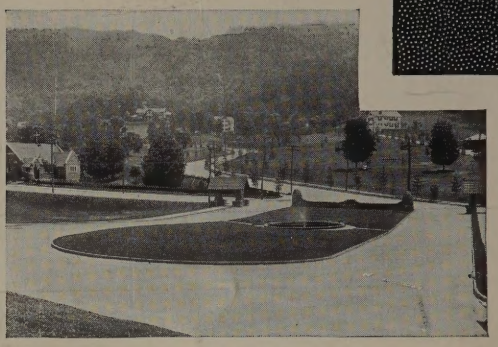


TEXACO Asphaltic Concrete in the famous Grove Park Section of Asheville, N. C. This pavement was built in 1917 on old macadam.

To combine beauty with durability. That was the paving problem in Asheville, N. C., America's famous resort. This problem was solved successfully by laying TEXACO Asphaltic Concrete.

Asheville now has thousands of square yards of durable, resilient TEXACO pavements, which harmonize in beauty with the entrancing scenic surroundings.



Another view of the TEXACO Asphaltic Concrete in Asheville, N. C., which was constructed in 1917.

Just as Asheville selected TEXACO pavements, so have many other world-famed resorts found TEXACO the most durable and serviceable.

Atlantic City and Long Branch in New Jersey, Mineral Wells in Texas, Florida's far-famed resorts, and many others have pavements that last—made of TEXACO Asphalt.

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